Space Technology Research Grants

Measurement and Modeling of Surface Coking in Fuel-Film Cooled Liquid Rocket Engines

Completed Technology Project (2016 - 2020)

Project Introduction

The development of future Kerosone/LOX engines will require higher chamber pressures to increase performance and reusability in order to decrease operating costs. However higher chamber pressures result in higher heat fluxes through the walls. This places greater stress on the cooling systems. Fuel film cooling is an effective method to reduce the heat flux, however since the fuel is not combusted, it reduces performance of the engine. Furthermore, an issue with using kerosene as coolant is coking that results from the thermal decomposition of the propellant. This decreases heat transfer and reduces the lifespan of the chamber material. This process has been previously studied in regenerative cooled chambers but the mechanisms for coke formation have not been well established. Additionally, in a fuel filmed cooled chamber the process is much more complicated with coking resulting from interactions with the liquid film and gaseous core flow. Currently the only models that exist for coking have been developed for the chemical and petroleum industries. The conditions inside a rocket combustion chamber however are much more severe and extrapolation of existing models will result in large error. Therefore coking models for rocket conditions are in need of development. For this project, an experimental and computational approach is proposed to understand the coking phenomena at rocket conditions. Experiments will be done to study coking behavior in a heated pipe reactor for the liquid fuel and for combusted gaseous products. SEM and an X-ray elemental detection analysis will be performed to determine the chemical characteristics of the coke layer. The results will be compared with another experiment that will involve coking in a liquid fuel film and gaseous core flow environment. Existing coke models will be modified to match the data at the higher pressure and temperature conditions from the experimental results. The end result would be an experimentally validated coking model that would serve to aid in the design of future reusable liquid booster engines and advance NASA's Launch Propulsion Systems Technology Roadmap.

Anticipated Benefits

The resultant experimentally validated coking model could serve to aid in the design of future reusable liquid booster engines and advance NASA's Launch Propulsion Systems Technology Roadmap.

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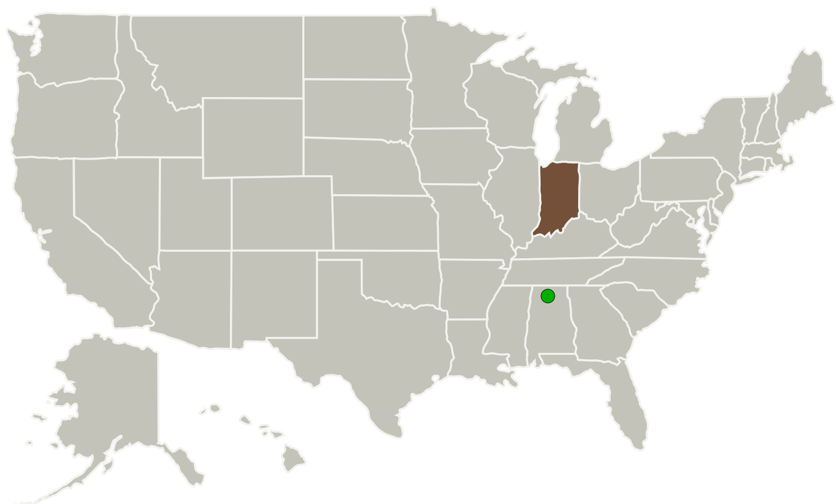
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Purdue University-Main Campus	Lead Organization	Academia	West Lafayette, Indiana
Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations
Indiana

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Purdue University-Main Campus

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

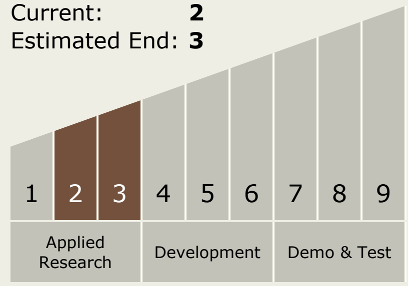
Timothee L Pourpoint

Co-Investigator:

Rufat F Kulakhmetov

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX01 Propulsion Systems
  - └ TX01.1 Chemical Space Propulsion
    - └ TX01.1.3 Cryogenic

Target Destination

Earth